ENVIRONMENTAL IMPACT OF STEEL BRIDGE CONSTRUCTION

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Victor Buyck Steel Construction (Eeklo - B)
Vrije Universiteit Brussel (B)
1. PROJECTS WILL BE EXAMINED ON THEIR SUSTAINABILITY PERFORMANCE

**TODAY: ALREADY REALITY**

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STEEL AT WORK

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STEEL AT WORK

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1. PROJECTS WILL BE EXAMINED ON THEIR SUSTAINABILITY PERFORMANCE

BREEAM
2. ENVIRONMENTAL IMPACT OF CONSTRUCTION WILL BE **DECISIVE** IN TENDER REVIEWS

**EXAMPLE 2**

From 1 January 2014 onwards, it will be legally required for **ALL CONSTRUCTION PRODUCTS** to declare EPD: Environmental Product Declaration.

From 1 January 2016: also transport component from 1 July 2017: EOL + Module D (EN 15804)
2. ENVIRONMENTAL IMPACT OF CONSTRUCTION WILL BE DECISIVE IN TENDER REVIEWS

EXAMPLE 1

CRITERIA:

A. Insight (into own carbon footprint)
B. CO2 reduction (recorded ambition)
C. Transparency (internal and external communication)
D. Participation in initiatives (with colleague companies in the field of CO2 reduction)

CRITERIA LEVEL 3:

° report CO2 emissions scope 1 & 2
° objectives for reduction
° communicate internally + externally
° active role in (sector) initiatives
2. ENVIRONMENTAL IMPACT OF CONSTRUCTION WILL BE DECISIVE IN TENDER REVIEWS

EXAMPLE 1

CRITERIA LEVEL 5:

° report CO2 emissions scope 1 & 2 (including A suppliers)
° objectives for reduction fully incorporated + publically committed
° communicate internally + externally
° participate in and initiate (sector) initiatives
SOONER or LATER
the environmental impact of
all human actions & activities
will be required to be determined
and will be required to be reduced,
thus also for
the steel construction industry
CHALLENGE FOR STEELWORK CONTRACTORS

CHALLENGE:
DEVELOP A METHOD TO DETERMINE YOUR CO2 AND ENERGY FOOTPRINT
CHALLENGE:
DEVELOP A METHOD TO DETERMINE YOUR CO2 AND ENERGY FOOTPRINT
ANALYSE THE PROCESS
+ APPLY ON REAL CASES
+ DETERMINE IMPROVEMENTS
= SET THE STANDARD
PRODUCT STAGE (A1, A2, A3):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit per kg</th>
<th>Production</th>
<th>Brand-lot*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary energy: non-renewable</td>
<td>Nm²</td>
<td>9.48</td>
<td>0.79</td>
<td>11.70</td>
</tr>
<tr>
<td>Primary energy: renewable</td>
<td>Nm²/ha</td>
<td>0.99</td>
<td>0.06</td>
<td>1.07</td>
</tr>
<tr>
<td>Climate Change Potential (2050)</td>
<td>kg CO₂ eq</td>
<td>1.88</td>
<td>0.08</td>
<td>1.96</td>
</tr>
<tr>
<td>Climate Decisive Potential (2050)</td>
<td>kg H2O eq</td>
<td>2.04</td>
<td>0.04</td>
<td>2.08</td>
</tr>
<tr>
<td>Acidification Potential (AP)</td>
<td>kg SO₂ eq</td>
<td>3.47</td>
<td>0.04</td>
<td>3.51</td>
</tr>
<tr>
<td>Eutrophication Potential (EP)</td>
<td>kg PO₄ eq</td>
<td>2.82</td>
<td>0.03</td>
<td>2.85</td>
</tr>
<tr>
<td>Photodissolution: Ozone Creat.</td>
<td>kg CH₄ eq</td>
<td>7.59</td>
<td>0.06</td>
<td>7.65</td>
</tr>
</tbody>
</table>

Recycling/re-use/scrap
CONSTRUCTION STAGE (A4, A5):
1. FABRICATION
2. CORROSION PROTECTION
3. TRANSPORT
4. ERECTION
5. OVERHEAD

CONSTRUCTION PHASE:
1. FABRICATION
2. CORROSION PROTECTION
3. TRANSPORT
4. ERECTION
5. OVERHEAD

TOTAL No. OF ACTIVITIES: 85
TOTAL No. OF INDIVIDUAL FACTORS: 200
CONSTRUCTION PHASE:
1. FABRICATION
   - grit-blasting
   - cutting (plates and sections)
   - drilling, punching, etc.
   - welding
   - manipulation
   - diesel for various machines
   - compressors

2. CORROSION PROTECTION
3. TRANSPORT
4. ERECTION
5. OVERHEAD
CONSTRUCTION PHASE
1. FABRICATION
3. CORROSION PROTECTION

3. TRANSPORT
° from rolling mill to factory
° internal transport factory
° from factory to construction site

4. ERECTION
° welding
° gases
° cranes, etc.: diesel

5. OVERHEAD
CONSTRUCTION PHASE:
1. FABRICATION
3. CORROSION PROTECTION
5. TRANSPORT
7. ERECTION

5. OVERHEAD (not project related)
° electricity offices
° heating
° ventilation
° lighting

CONVERSION FACTORS
Machines and tools (electricity)

\[ E = n \varphi \lambda P \text{ [kWh]} = 3.6 n \varphi \lambda P \text{ [MJ]} \]

- \( P \) declared power of the machine [kW];
- \( n \) total number of working hours reported by the operator [h];
- \( \lambda \) load factor: percentage of full capacity that has been used [%];
- \( \varphi \) effectivity: effective working time of the machine divided by reported working time of the operator [%].

\[ \text{GWP} = 0.615 n \varphi \lambda P \text{ [kgCO2eq]} \]
CONVERSION FACTORS

Machines and tools (electricity)

\[ E = n \varphi \lambda P \text{[kWh]} = 3.6 n \varphi \lambda P \text{[MJ]} \]

<table>
<thead>
<tr>
<th></th>
<th>Load factor</th>
<th>Effectivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranes (workshop)</td>
<td>50%</td>
<td>60%</td>
</tr>
<tr>
<td>Compressor (workshop)</td>
<td>30%</td>
<td>100%</td>
</tr>
<tr>
<td>Ventilation (workshop)</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Plate oxy-cutting (workshop)</td>
<td>40%</td>
<td>100%</td>
</tr>
<tr>
<td>Drilling, punching, sawing (workshop)</td>
<td>60%</td>
<td>70%</td>
</tr>
</tbody>
</table>

CONVERSION FACTORS

Consumables

- propane
- natural gas
- acetylene
- diesel
- thinners
- zinc metal spray

Example: diesel

\[ E = 3.6 c_{\text{die}} v_{\text{die}} \text{[MJ]} \]
\[ \text{GWP} = 3.135 v_{\text{die}} \text{[kgCO2eq]} \]

Calorific value: \( c_{\text{die}} = 11.61 \text{ kWh/l} \)

Volume \( v_{\text{die}} \text{[l]} \)
CONVERSION FACTORS

Handbook CO2 performance ladder; edition 2.0 (23 June 2011)

HANDBOOK
CO2-PERFORMANCELADDER 2.0

23 June 2011

110 pages

CONVERSION FACTORS

Handbook CO2 performance ladder; edition 2.0 (23 June 2011)

Electricity consumption

<table>
<thead>
<tr>
<th>A</th>
<th>Grey power</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 and earlier</td>
<td>500</td>
</tr>
<tr>
<td>2006</td>
<td>550</td>
</tr>
<tr>
<td>2007 and 2008</td>
<td>550</td>
</tr>
<tr>
<td>2009</td>
<td>670</td>
</tr>
<tr>
<td>2010 and later</td>
<td>670</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B</th>
<th>Grey power</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 and earlier</td>
<td>15</td>
</tr>
<tr>
<td>2006</td>
<td>15</td>
</tr>
<tr>
<td>2007 and 2008</td>
<td>80</td>
</tr>
<tr>
<td>2009</td>
<td>80</td>
</tr>
<tr>
<td>2010 and later</td>
<td>80</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C</th>
<th>Other green power consumed as of 1 July 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005 and earlier</td>
<td>500</td>
</tr>
<tr>
<td>2006</td>
<td>500</td>
</tr>
</tbody>
</table>

Source A: The conversion factor of the Basic Rate was reduced to 1 July 2012. The rate in 2005 is 1500 g CO2/kWh. The electricity consumed in 2005 is 7000 GWh. For the Basic Rate, the electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh.

Source B: The conversion factor of the Basic Rate was reduced to 1 July 2012. The rate in 2005 is 1500 g CO2/kWh. The electricity consumed in 2005 is 7000 GWh. For the Basic Rate, the electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh.

Source C: The conversion factor of the Basic Rate was reduced to 1 July 2012. The rate in 2005 is 1500 g CO2/kWh. The electricity consumed in 2005 is 7000 GWh. For the Basic Rate, the electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh. The electricity consumed in 2005 is 7000 GWh.

was 615 in earlier version
### CONVERSION FACTORS

**Handbook CO2 performance ladder; edition 2.0 (23 June 2011)**

#### A. Freight transport in general

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>g CO₂ per tne km</th>
<th>Source: DE Braak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Petrol</td>
<td>2.785</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>3.135</td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>1.880</td>
<td></td>
</tr>
<tr>
<td>Fuel oil</td>
<td>2.145</td>
<td></td>
</tr>
<tr>
<td>Bio-ethanol</td>
<td>1.400</td>
<td></td>
</tr>
</tbody>
</table>

**B. Transport of bulk cargo**

<table>
<thead>
<tr>
<th>Cargo Type</th>
<th>g CO₂ per tne km</th>
<th>Source: DE Braak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck &lt; 20 tonnes</td>
<td>295</td>
<td></td>
</tr>
<tr>
<td>Truck &gt; 20 tonnes</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Tractor with trailer</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Electric</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Diesel</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Combination *1</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>150 tonnes</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>350 tonnes</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>1,850 tonnes</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>5,500 tonnes</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>1,800 tonnes</td>
<td>75</td>
<td></td>
</tr>
<tr>
<td>8,000 tonnes</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>10,000 tonnes</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

*1 Combination means: transport purity by physics and purity by diesel locomotive, or transport with unknown locomotive types. Recalculation not obligatory.
CONVERSION FACTORS

List emission factors via www.milieubarometer.nl

RESULTS

5 STEEL BRIDGE PROJECTS, all recently completed

Railway bridges over the river Nete – Duffel (B)
RESULTS

5 STEEL BRIDGE PROJECTS, all recently completed

Bowstring bridge over the Albert canal – Grobbendonk (B)

RESULTS

5 STEEL BRIDGE PROJECTS, all recently completed

Bowstring bridge - Luxemburg
RESULTS

5 STEEL BRIDGE PROJECTS, all recently completed

Bridge Madeleine over the river Loire – Nantes (F)

Lock doors + bridge Kattendijk – Antwerp (B)
### RESULTS

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Steel consumption</th>
<th>Dimensions</th>
<th>Description</th>
<th>Fabrication hours</th>
<th>Corrosion protection system</th>
<th>Distance workshop to site</th>
<th>Transport to site</th>
<th>Erection method</th>
<th>Erection hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grobbendonk</td>
<td>573 t</td>
<td>L = 109 m</td>
<td>Bowstring; Fully welded; Concrete</td>
<td>25.3 h/t</td>
<td>3 layers (240 µm)</td>
<td>100 km</td>
<td>Barge (over canals)</td>
<td>Float in</td>
<td>6.2 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B = 18 m</td>
<td>deck on steel cross girders</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Launching</td>
<td>9.9 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = 15.5 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In situ</td>
<td>6.2 h/t</td>
</tr>
<tr>
<td>Duffel</td>
<td>2,280 t</td>
<td>L = 110 m</td>
<td>Bowstring; Fully welded; Orthotropic</td>
<td>22.0 h/t</td>
<td>Zinc spray + 2 layers (150 µm)</td>
<td>100 km</td>
<td>Truck</td>
<td>Float in</td>
<td>5.4 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B = 13 m</td>
<td>deck</td>
<td></td>
<td>or 3 layers (arch) (200 µm)</td>
<td></td>
<td></td>
<td>Launching</td>
<td>5.4 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = 20 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In situ</td>
<td></td>
</tr>
<tr>
<td>Luxemburg</td>
<td>1,954 t</td>
<td>L = 122 m</td>
<td>Bowstring; Bolted cross girders;</td>
<td>10.4 h/t</td>
<td>Zinc spray + 2 layers (140 µm)</td>
<td>300 km</td>
<td>Truck</td>
<td>Float in</td>
<td>5.4 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B = 18.5 m</td>
<td>Concrete deck</td>
<td></td>
<td>or 3 layers (arch)</td>
<td></td>
<td></td>
<td>Launching</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = 20.5 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>In situ</td>
<td></td>
</tr>
<tr>
<td>Nantes</td>
<td>2,527 t</td>
<td>L = 210.5 m</td>
<td>Cable stayed; Fully welded; Orthotropic</td>
<td>23.5 h/t</td>
<td>3 layers (230 µm); interior of pylon; 1 layer (40 µm)</td>
<td>1,200 km (over sea)</td>
<td>Truck</td>
<td>Fully completed</td>
<td>2.4 h/t</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B = 13 m</td>
<td>deck</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>in situ</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = 5.4 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kattendijk</td>
<td>(bridge) 254 t</td>
<td>L = 69 m</td>
<td>(bridge) Truss; Fully welded;</td>
<td>35.7 h/t</td>
<td>(bridge) 4 layers (140 µm)</td>
<td>100 km</td>
<td>Ship (doors) and barge (bridge)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Antwerp</td>
<td>(doors) 417 t</td>
<td>B = 13 m</td>
<td>Fully welded</td>
<td></td>
<td>(doors) 2 layers (150 µm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>H = 5.4 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Energy consumption**

- **Overhead**: 1,854 kg CO₂/t
- **Erection**: 1,257 kg CO₂/t
- **Transport**: 512 kg CO₂/t
- **Corr. Protection**: 41 kg CO₂/t
- **Fabrication**: 202 kg CO₂/t

**Total**: 5,099 kg CO₂/t
RESULTS

<table>
<thead>
<tr>
<th>Bridge</th>
<th>Fabrication</th>
<th>Corrosion protection</th>
<th>Transport</th>
<th>Erection</th>
<th>Overhead</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MJ/t/kg CO2/t</td>
<td>MJ/t/kg CO2/t</td>
<td>MJ/t/kg CO2/t</td>
<td>MJ/t/kg CO2/t</td>
<td>MJ/t/kg CO2/t</td>
<td>MJ/t/kg CO2/t</td>
</tr>
<tr>
<td>Grobbendonk</td>
<td>951/150</td>
<td>592/139</td>
<td>625/47</td>
<td>626/51</td>
<td>1,854/109</td>
<td>4,648/496</td>
</tr>
<tr>
<td>Duffel</td>
<td>868/133</td>
<td>755/137</td>
<td>224/17</td>
<td>941/77</td>
<td>1,821/106</td>
<td>4,609/470</td>
</tr>
<tr>
<td>Luxembourg</td>
<td>572/88</td>
<td>516/70</td>
<td>416/31</td>
<td>701/57</td>
<td>1,008/59</td>
<td>3,213/305</td>
</tr>
<tr>
<td>Nantes</td>
<td>867/129</td>
<td>393/96</td>
<td>416/31</td>
<td>818/63</td>
<td>1,777/104</td>
<td>6,577/596</td>
</tr>
<tr>
<td>Kattendijk</td>
<td>1,257/194</td>
<td>702/172</td>
<td>701/57</td>
<td>204/63</td>
<td>2,260/132</td>
<td>5,099/565</td>
</tr>
</tbody>
</table>

**CO2 emission**

- Overhead
- Erection
- Transport
- Corrosion protection
- Fabrication

**CO2-emission Fabrication Projects**

- Compressed air
- Diesel other machines
- Manipulating
- Welding
- Preparations: drilling, punching, punching
- Burning, sawing
- Blasting
RESULTS

CO2 emission

kg CO2/ton

STEEL AT WORK

ENVIRONMENTAL IMPACT OF STEEL BRIDGE CONSTRUCTION

04-12-2012
CONCLUSIONS

1. Difference fully welded bridge vs bolted bridge:

   300 kgCO2eq/t vs 200 kg CO2eq/t
   (fabrication + erection + overhead)
   (excluding corrosion protection + transport)

   14 kgCO2eq/h vs 16.5 kgCO2eq/h
   (overall)

2. Transport

   It is ecological MADNESS to import large fabricated steel structures from far overseas.

   EXAMPLES:
   - 12,000 tons lock doors + bridges for the new lock in Antwerp Waasland harbour
   - 5 container cranes Zeebrugge harbour
   - 12,000 tons lock doors + bridges for the new lock in Antwerp Waasland harbour
CONCLUSIONS

EXAMPLE:

12,000 tons lock doors + bridges for the new lock in Antwerp (Waasland harbour) .... made in China

CONCLUSIONS

EXAMPLE:

Norway: Hardanger bridge .... made in China
CONCLUSIONS

EXAMPLE:

Germany: Wilhelmshafen
.... made in China

CONCLUSIONS

EXAMPLE:

12,000 tons lock doors + bridges for the new lock in Antwerp (Waasland harbour)

Key figures:
° Direct gain of 8 million EUR
° Indirect loss of 14 million EUR
° Resulting loss of 6 million EUR
° transport: 850 kgCO2eq/t
  or 10,000,000 kgCO2eq !
CONCLUSIONS

3. It is possible to determine the ecological footprint of the steel construction industry

4. There is a relationship between the ecological footprint and the complexity of the structure (hours)

5. Research can be further fine tuned:
   a. More data  -> challenge for the sector
   b. More precise data  -> registration, measuring
   c. Wider range  -> other type of structures
   d. Effective actions  -> reduction programmes
   e. Wider perspective  -> immediate effects

Victor Buyck is ready to make the (next) step, what about you?
Remember:

steel fabrication is only a small part after all

Planet earth thanks you!